Production, Identity Preservation, and Labeling in a Marketplace with Genetically Modified and Non-Genetically Modified Foods[1]

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As the demand for food and fiber grew during the past 300 years, because of the Earth's expanding human population and rising per capita incomes, society met this demand first by increasing the land area under cultivation and later by improving crops so that their yields were higher. Before 1900, land was abundant almost everywhere, and in the United States, new lands were brought into production as the frontier moved across the country between 1700 and 1900. In addition, the great crop exchange between different continents permitted high-yielding crops like potatoes (*Solanum tuberosum*) to be grown in Europe and rice (*Oryza sativa*) in the United States. Improvement was by selection of the fittest in the new environment. By 1900, the frontier was closed in the United States, and this increased the urgency of finding new methods for increasing crop yields.

GENETIC CROP IMPROVEMENT

Genetic crop improvement or plant breeding is a 20th century phenomenon. Gene exchange occurs only in sexually compatible species. Most of the genetic variation is created through crossing. Selection is conducted by measuring plant characteristics such as grain yields, and the genes that underlie these characteristics are unknown. Conventional breeding does not require knowledge at the DNA level (Lamkey, 2002).

In the United States, plant breeding for almost all crops was undertaken first in the public sector by the U.S. Department of Agriculture and the State Agricultural Experiment Stations, and then, wherever large markets for seed existed and genetic improvements could be protected, the private sector emerged as a major source of crop improvement. In self-pollinated crops like small grains and soybeans (*Glycine max*), protection of crop improvements largely did not exist before the early 1970s, when plant variety protection legislation was enacted. In the case of cross-pollinated crops such as corn (*Zea mays*) and sorghum (*Sorghum bicolor*), hybridization discovered early in the 20th century proved a type of natural protection to developers/discoverers of genetic improvement because hybrids cannot reproduce themselves.

Hybrid corn, however, was not a commercial success in the United States until after the first commercial double cross was developed in 1920. More than an additional decade was required before superior double-cross varieties were generally available to farmers in the Midwest (Griliches, 1960; Huffman and Evenson, 1993). Starting in the 1930s, hybrid corn varieties jointly developed by the public and private sectors rapidly replaced open-pollinated corn varieties. Farmers in the center of the U.S. Corn Belt were the first to have superior hybrids made available to them because that region promised the greatest profits to the seed companies. The new hybrids were rapidly adopted by farmers, despite the additional cost, because they were profitable (Griliches, 1960). Outside the Corn Belt, superior hybrids were made available later and they were less rapidly adopted by farmers (Griliches, 1960). Thirty-five years later, single crosses largely replaced double crosses and in the Midwest, the private sector hybrid corn companies, e.g. Pioneer, DeKalb, Pfister, Funk Seeds, soon took control of the development of corn hybrids, commercial reproduction, and commercial distribution. In contrast, for small grains, soybeans, legumes, and grasses, the public sector remained an important developer of new varieties (Huffman and Evenson, 1993). In other developed countries (Europe, Japan, Australia, etc.), the public sector was also the main developer of improved crop varieties.

THE GREEN REVOLUTION

For the developing countries, the production of modern crop varieties started in earnest in the 1950s. In the mid-1960s, scientist developed modern varieties of rice and wheat that were subsequently released to farmers in Latin America and Asia. The success of these modern varieties has been called the "Green Revolution." The new rice and wheat varieties were rapidly adopted in tropical and subtropical regions

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with good irrigation systems or reliable rainfall. These modern varieties were associated with the first two major international agricultural research centers—the International Center for Wheat and Maize Improvement in Mexico and the International Rice Research Institute in the Philippines.

Evenson and Gollin (2003) show that over the period from 1960 to 2000, the international agricultural research centers, applying largely traditional breeding techniques, in collaboration with national research programs but with negligible private sector input, contributed to the development of modern varieties for many crops. These varieties contributed to large increases in crop production in Asia and Latin America. Green Revolution productivity gains, however, have been uneven across crops—larger in rice and wheat than other crops—and across regions—largest in Asia and Latin America and very small in Africa. Consumers in developing countries generally benefited from declines in food prices relative to other purchases of household, which have averaged about 1% per year since 1960, and farmers in developing countries benefited only when cost reductions exceeded price reductions (Evenson and Gollin, 2003). One striking feature is that gains from modern varieties were larger in the 1980s and 1990s than in the preceding two decades—despite popular perceptions that the Green Revolution was effectively over by the 1980s. Overall, the productivity data suggest that the Green Revolution is best understood not as a one-time jump in yields, occurring in the late 1960s, but rather as a long-term increase in the trend growth rate of productivity. This occurred because successive generations of modern varieties were developed, each contributing gains over previous generations.

Evenson and Gollin (2003) show that without the Green Revolution, crop yields in developing countries would have been 20% to 24% lower and equilibrium prices for all crops combined would have been from 35% to 66% higher in 2000 than they actually were. Taking area and yield effects together, crop production in developing countries would have increased land in production in developing countries by 14% to 19%. With food prices much higher, caloric intake per capita would have been 14% lower, which would have dramatically increased malnourishment among children and adults. Unfortunately, during the 1990s, the donors (North America, western Europe, and Japan) dramatically reduced their financial support to the international agricultural research system. This has harsh implications for people living in less developed countries.

THE GENE REVOLUTION

The 1990s brought us the "Gene Revolution" in crop improvement. Genetic modification of this era is a relatively new and complex process that involves insertion of a gene, often from a different species, into a plant or animal. The process is sometimes referred to as genetic engineering and genetic modification, and the crops are referred to as genetically modified (GM) organisms (GMOs), or just GM crops. Since the beginning of farming, farmers and others have been genetically modifying plants to enhance the quantity of desirable attributes. However, since the early 1990s, the term "genetic modification" has been associated with a much narrower set of techniques that use recombinant DNA or gene splicing technology to facilitate the transfer of genes across species. (In 1973, Cohen and Boyer discovered the basic technique for recombinant DNA, which launched a new field of genetic engineering. The Cohen-Boyer patent on gene-splicing technology was awarded in 1980 to Stanford University and the University of California [Office of Technology Assessment 1989]. They built on the 1953 discovery by Watson and Crick of the structure of DNA and of the suggestion about how it replicates.) Foods made using this type of GM material have become known commonly as GM foods.

Major GM crop varieties became available to U.S. farmers starting in the mid-1990s with insect-resistant (bT) cotton (*Gossypium hirsutum*), herbicide-tolerant, e.g. "Round-Up Ready" (RR), cotton, soybean, and corn. Later, insect-resistant (e.g. bT) corn became available. Insect-resistant technology uses *Bacillus thuringiensis*, which encodes proteins that are toxic to plant-feeding insects, and RR technology uses plants that have been encoded with a protein, the enzyme mEPSPS, which makes the plant tolerant to glyphosate, the active ingredient in Roundup herbicide. When Round-Up is applied to a RR crop variety, every plant is killed, except for the RR plants. Herbicide-tolerant soybeans are now planted upon roughly 70% of the U.S. soybean acreage, and herbicide-tolerant cotton is planted on roughly 55% of cotton acreage (See Fig. 1). Bt cotton is planted on roughly 38% of U.S. cotton acreage, but insect-resistant and herbicide-tolerant corn are planted on less than 20% of U.S. corn acreage (U.S. Department of Agriculture, 2003).

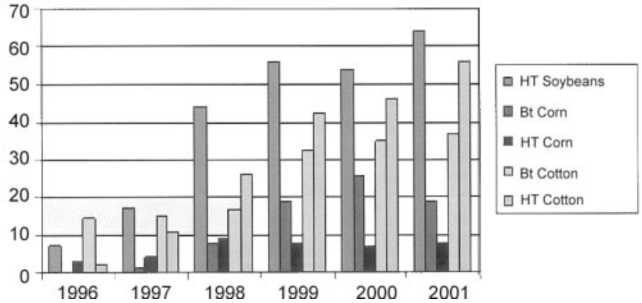

Figure 1. Percent of crop acres planted to herbicide-tolerant (HT) and Bt (BT) crop varieties in the United States, 1996–2000. Source: Economic Research Service, U.S. Department of Agriculture.

Bt technology has been effective in reducing insecticide application rates dramatically in cotton in the southern United States (Falck-Zepeda et al., 2000) and in India (Qaim and Zilberman, 2003). It replaced chemical insecticides that are quite toxic to the environment and humans. RR soybeans brought more effective weed control into the management toolkit of the poorest farm managers, although some extension agricultural economists (e.g. Duffy, 2002) indicate very little difference in the cost of production for RR soybean varieties relative to traditional soybean varieties (they fail to count the value of reduced risk of effective weed control due to weather or other delays using conventional practices) and bean yields would be expected to be higher. Farmers, however, find the technology to be easy to apply, not timing critical, and effective in a 2-year crop rotation. These are undoubtedly the reasons why RR soybeans and cotton have been such large commercial successes in the United States (U.S. Department of Agriculture, 2003).

THE GM CONTROVERSY

The application of GM technology to crop production has been hailed by some as the greatest invention since the beginning of farming, e.g. by the biotech industry (Council for Biotechnology Education), but international environmental groups such as Greenpeace, Friends of the Earth, and Action Aid counter that GM technology has not been proven safe for humans or the environment, that it benefits only big business and not the consumers, and that it creates "Frankenfoods" (e.g. see Greenpeace International, 2003). The growing controversy over GM food products and consumers' attempts to make better food purchasing decisions have stimulated interest in food labeling, identity preservation, and new sources of information (Caswell, 2000). For example, two international non-governmental organizations (NGOs), Greenpeace and Friends-of-the-Earth, believe that GM labeling would benefit consumers and these groups advocate labels on GM foods to give consumers the right to choose whether or not to consume GM foods (Friends of the Earth, 2001; Greenpeace International, 2001). In fact, they have demanded mandatory labeling, which they believe would benefit consumers. Microbial contamination of foods, however, is a much greater food safety concern (even in developed countries, let alone developing countries) than GM content, but in the case of GM foods, the international NGOs have made GM food their number one issue, and a surrogate issue at that, according to some (Nestle, 2003).

LABELING, SEGREGATION, AND IDENTITY PRESERVATION

In the United States, truthful labeling has been used historically to provide consumers with information on calories, nutrients, and food ingredients, under regulatory guidelines. But the federal government only requires explicit labeling of GM food if it has distinctive characteristics relative to the non-GM version (Caswell, 2000). In contrast, the European Commission adopted GM food labels in 1997. The Commission requires each member country to enact a law requiring labeling of all new products containing substances derived from GM organisms. Japan, Australia, and many other countries have also passed laws requiring GM labels for major foods. The international environmental lobby has frequently argued that "consumers have the right to know whether their food is GM or not" (Greenpeace International, 2001). Labeling, however, involves real costs, especially the costs of testing for the presence of GM, segregating the crops, variable costs of monitoring for truthfulness of labeling and enforcement of the regulations that exist, and risk premiums for being out of contract (Wilson and Dahl, 2002).

An effective labeling policy also requires effective segregation or an "identity preservation system." To the extent that there is a market for non-GM crops, buyers of crops would be expected to specify in their purchase contracts some limit on GM content and/or precise prescriptions regarding production/marketing/handling processes (Wilson and Dahl, 2002). One can envision a marketplace of buyers with differentiated demand according to their aversion to GM content. To make this differentiation effective, new costs and risks are incurred. Additional testing involves costs of conducting the tests for which there are several technologies of varying accuracy. The risk is that GM and non-GM varieties will be commingled and detected in customers' shipments under contract limits on GM content. This is a serious economic problem as agents seek to determine the optimal strategy for testing and other risk mitigation strategies.

"Tolerances" are an important issue in identity preservation and segregation. Tolerance refers to the maximum impurity level for GM content that is tolerated in a product that still carries the non-GM label. There are two levels where tolerances apply: one is defined by regulatory agencies such as the Food and Drug Administration, and the other is commercial tolerances. Individual firms can and seem likely to adopt different tolerances, subject to any regulation. Moreover, different countries are likely to have different tolerance levels and this increases the risks and costs of identity preservation.

Dual market channels could develop privately without regulated tolerance levels. However, this system would require growers to declare GM content at the point of first delivery and be subject to their own uncertainty about GM content. This is commonly referred to as "GM Declaration" and has been an important element of the evolution of markets for GM grains (see Harl for a discussion of the Opportunities and Problems in Agricultural Biotechnology, 2001). At the delivery point, a grain elevator could segregate within its own facilities, or each elevator could specialize in handling only GM versus non-GM grain. Or, it could be a vertically integrated firm with some delivery points specializing in GM and others in non-GM commodities or different GM commodities.

Major risks arise in segregation and identity preservation. Growers face three sources of risk: (a) "volunteer or feral plants" in subsequent crops, (b) pollen drift, and (c) on-farm adventitious commingling (Wilson and Dahl, 2002). The volunteer-plant rate is highest during the 1st year after planting a crop and decreases as subsequent years pass. At some cost to farmers, this population can be reduced through mechanical weeding or selective application of chemical herbicides. Pollen drift is modest in self-pollinated crops, e.g. wheat, rice, and soybeans, but very high in open-pollinated crops, e.g. corn and sorghum. Even in self-pollinated crops, outcrossing occurs at a nonzero rate for most plants (Hucl and Matus-Cadiz, 2001). Farmers can reduce the likelihood of pollen drift in the crops by establishing physical barriers (buffer strips) and physiological barriers (staggering pollination dates). (In gene flow experiments in a corn growing region of Mexico, Luna et al. [2001] showed that cross-pollination rates drop off rapidly as distance between pollen source and recipient plants increases. They found slight cross-pollination rates at 150 m and none at 300 m.) On-farm adventitious commingling can be expected to occur at a significant rate on farms producing GM and/or non-GM crops, and other GM crops. This problem would decrease as a farmer becomes more specialized in one non-GM crop, but if this resulted in more monocultures, then it would increase costs from pests that thrive on monocultures, soil erosion, and higher commercial fertilizer rates.

Although private sector handlers routinely segregate and blend grains as a primary function of their business, new risks arise when handling GM grains due to the added risk of adventitious commingling. (Wilson and Dahl [2002] estimate that the cost of segregation with a varietal declaration system is much less expensive than for an identity preservation system.) Currently in the United States, this risk may be about 4% at the elevator level (Wilson and Dahl, 2002). Farmer-processor contracting of specialty crops, however, could reduce this margin by specializing in the product being delivered. Another source of risks is testing, because no test is 100% accurate. This risk, however, varies with the technology, tolerance, and variety of products handled, and seems likely to be falling over time as the technology of testing advances.

In a recent study, Tegene et al. (2003) showed that with current GM technology, standard-labeled and non-GM-labeled products would sell at a premium. Hence, growers and handlers of non-GM grains have a private incentive to "signal" their "superior quality." This signaling is, however, costly, i.e. it involves segregation and identity preservation. Because GM grains would currently sell at a discount, GM growers and handlers do not have any incentive to undertake costly identifying and segregating non-GM from GM grains. In fact, because non-GM would sell for more, they have an incentive for adventitious commingling of GM and non-GM products. Hence, only products destined to be non-GM would need to be tested. Furthermore, setting of tolerance levels must take into consideration that the science of detection of impurity is steadily rising, so "a zero tolerance level" is very costly. Furthermore, Rousu et al. (2003b) have shown that consumers would pay a significant amount for what they perceived as a zero-tolerance level in vegetable oil, tortilla chips, and russet potatoes, but they were indifferent between a 1% and a 5% tolerance level, i.e. indifferent between a non-GM labeled product with 1% and 5% GM impurity rate.

In a marketing system with identity preservation or segregation, end-users and buyers would need to express their needs and aversions to GM in contracts with tolerances. Ultimately, it is incumbent on those buyers wanting to limit GM content in non-GM shipments to specify limits/restrictions in their purchase contracts. Those who are not averse to GM would not have to do anything special. Grower declarations on grain shipped is, however, a critical first-step in this process. Hence, it is important that growers know the purity of the varieties they plant or at least have the capability of knowing. This provides a wealth of information that needs to be conveyed to the marketing system. To the extent that farmers do not have perfect control of their production process, e.g. use purchased seed that may not be 100% non-GM, grow crops in the open-air where windblown contamination can occur rather than in greenhouses, and produce both GM and non-GM crops, which leads to adventitious commingling, they may be reluctant to declare that their delivery of grain is GM-free.

SEARCH FOR OBJECTIVE INFORMATION

Information is frequently scarce about new agricultural technologies, and GM technology is no exception. Advances in science enable new technologies, and advances in technology increase the demand for science. Advancing science and technology are, however, uncertain and costly activities (Huffman and Evenson, 1993). Although some new technologies have benefited society greatly, much uncertainty surrounds all new technologies. For example, little accurate information or knowledge exits about the attributes of new agricultural biotechnologies, and some of the information is in the public domain, whereas other information is privately held. Additional research can be undertaken to increase the knowledge about the beneficial and harmful effects of new technologies, some of which will reduce the uncertainty over future irreversible catastrophes. However, it makes no economic sense to apply the European Union's precautionary principle (for a discussion of the precautionary principle, see van den Belt, 2003) to extensively test a new crop variety for potential human or environmental hazards before releasing it (Paarlberg, 2001). And there are only slight political reasons to do so (Buttel, 2003). This principle is anti-science because it is scientifically impossible to prove with 100% certainty that some event will not occur in the future. Furthermore, this standard has not been applied to other new crop technologies, e.g. hybrid corn, herbicide control of weeds, and commercial fertilizer supplementation of soil nutrients, or pasteurization of milk, beer, and wine.

Advances in communication and information networks make possible rapid worldwide dissemination of public scientific discoveries and other information. Private information is the source of asymmetric information, and it leads to an informational advantage to the party possessing it (Mohol, 1997). In two-party interactions with one party possessing private information, the informed party can be expected to exercise its information advantage whenever it expects to profit from it with the result that the other party loses. When experienced parties develop intuition about situations potentially leading to opportunistic behavior of others, asymmetric information can destroy trade/exchange between parties where the potential gains from trade/exchange are large.

Many agents must or choose to rely on information provided by individuals or groups that are affected by their decisions. Sometimes, these agents do not know the alternative available and have no control over the information provided to them by interested parties. These interested parties may distort or conceal information, thereby manipulating the decision-making process. For example, consumers rely on information and advertising distributed by food companies, the biotechnology industry, and environmental groups that seem likely to be tainted by self-interest. For example, communications by Greenpeace and Friends of the Earth opposing GM foods may exaggerate the potential harm to the environment and distract from other important issues, and agricultural biotech companies may underemphasize potential future environmental harm of GM crops and overemphasize the production cost saving (Council for Biotechnology Information, 2001).

Greenpeace, Friends of the Earth, and other international NGOs are interest groups. Individuals who join such groups are self-selected and have a common interest or goal focused on the environment and on achieving the group's goal, which is seen as a public good by its members. Hence, free-riding by one member on the efforts of other members is a major organization problem (Sandler, 1992). However, each of these groups has resources—largely members' time and financial contributions—and the group's impact is affected by organizational efficiency. By choosing narrow objectives, these groups reduce coordination and decision-making costs over organizations that have diverse goals (Sandler, 1992). Advances in communications and information technologies have greatly reduced organizational costs of interest groups and have undoubtedly increased their productivity. They are now able to construct low cost Web sites for displaying their objectives, news releases, short articles, and other information. These groups can also use e-mail to rapidly distribute communications among members, for example dealing with demonstrations, and others, such as letters opposing GMO use and policies.

If information provided by interest groups is verifiable at a low cost, then agents can be unsophisticated, having little or no idea of the available options, of issues bearing on the decision or preferences of the interested party. He or she must, however, be able to process the information received. Under these conditions, fully informed decisions are possible (Huffman and Tegene, 2002). Much information being distributed these days about agricultural biotechnology, however, is currently not verifiable. First, biotechnology is advancing rapidly so many effects and impacts of new products are unknown. Second, a coalition of anti-biotechnology interests has been formed to slow the acceptance of the technology. These groups have raised new questions about both the short- and long-term effects on health and the environment of using this technology. Third, some of the activists of anti-biotech groups have disrupted/destroyed the very experiments that might lead to important and useful advances in the stock of knowledge about agricultural biotechnology. When information is not verifiable, communications by interested parties may lead to unduly restrictive public policies being adopted, or it might degrade the information content to the extent that sophisticated agents ignore it. These will, however, be generally social welfare reducing relative to fully informed decision making.

EFFECTS OF GM FOOD LABELS AND DIVERSE INFORMATION

Using data generated from a project that employs a hybrid methodology (one built on sample survey methods, statistical experimental design, and experimental economics), Huffman et al. (2003) analyze laboratory auction data collected from consumers in two large metropolitan areas. Participants were adults who were paid $40 to come to a central location (i.e. a classroom) and participate in an experiment dealing with group decisions on consumer choice of food and household products. The choice of adults rather than university students is a major advantage when the products to be auctioned are ones that are sold in grocery stores and supermarkets. Students acquire a large share of their food from group eating arrangement (restaurants and cafeterias).

In the Huffman et al. experiments, two types of labels were used; one was a "standard food" label that read, for example, "32 ozs. of vegetable oil," and the other was a label that also indicated that the product was "made using genetic modification (GM)." They defined three perspectives on genetic modification: the biotech industry perspective, e.g. Monsanto and Syngenta; the environmental group perspective, e.g. Greenpeace; and independent, third-party perspective, e.g. of well-informed scientists and professions at the time of the experiments who had no significant financial interest in agricultural biotechnology. Information under these three perspectives was organized into five categories: general information, scientific impact, human impact, financial impact, and environmental impact. The three perspectives were grouped into six packets: the industry perspective, the environmental group perspective, the industry and environmental perspective, the industry perspective and third party, the environmental group and third party, and all three types of information. The two labeling treatments and six information treatments were randomly assigned to experimental units of 13 to 16 individuals with two replications.

The type of laboratory auction was a random *n*th price, in which the winner was chosen as follows. If there were 16 participants and the random *n* was 5, then the four highest bidders would pay the 5th highest price. This type of auction reduces the frequency of insincere bidding, because all participants have a non-zero probability of winning the auction. To eliminate problems caused by participants having a negatively sloped demand for a particular food item, the institutional structure of the auction was set such that no one individual would purchase more than one unit of any product. Furthermore, we told the participants that they would at most be the winner of one unit of an auctioned commodity, meaning that they would have to pay at the close of the experiments for at most one unit of each auctioned commodity.

In these bidding experiments, 172 participants discounted GM-labeled foods by an average of 14% relative to their standard-labeled counterpart (Huffman et al., 2003). Also, Figure 2, however, shows that the difference between bids for GM-labeled and plain-labeled foods was small but skewed slightly to the left. A participant's gender, household income, age, or education had no significant effect on his/her willingness to pay for auctioned commodities. Individuals, who claimed to be "informed about genetic modification" in pre-auction questionnaires, however, discounted GM-labeled commodities more heavily than other participants, suggesting that their

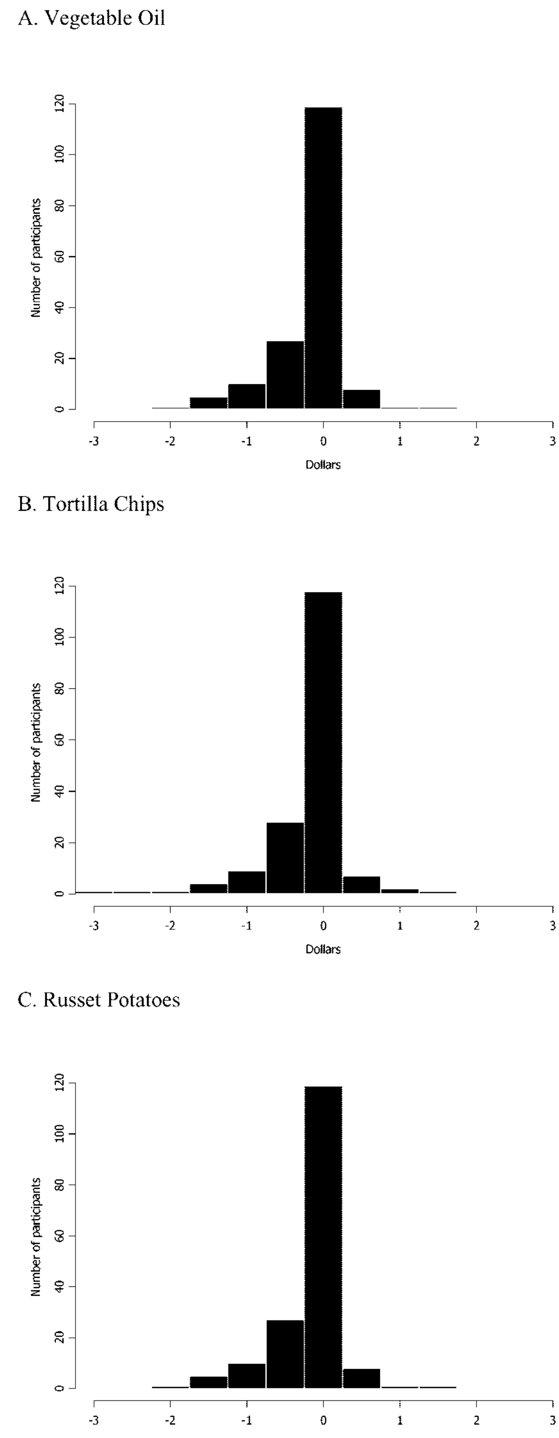

Figure 2. Histogram for an individual's bid price difference: bid on GM-labeled less the bid on a plain labeled food item, three different food items. A detailed description of how these experiments were conducted is included in the text.

prior information about genetic modification was negative.

Participants in these auctions revealed that verifiable information is a moderating force on consumers' willingness to pay for foods that might be GM in a market with conflicting information, i.e. where the biotech industry perspective is injected, where the environmental group perspective is injected, or where the biotech industry and environmental group perspectives are injected before the independent, third-party perspective is injected. They found a positive, although small per lab participant value for verifiable information on GM foods. Extending these results to cover annual sales of U.S. processed foods; their results suggested that verifiable information on genetic modification has a large annual social value to U.S. consumers—roughly several billion dollars annually (Rousu et al., 2003a).

CONCLUSIONS

We might argue that only low-risk agricultural technologies should be employed by farmers and that consumers' have the right to know whether their foods are genetically modified. Producers, handlers, and processors could be made responsible for guaranteeing the purity and safety of food crops. This could be accomplished by enacting new federal consumer-protection legislation. However, this would be very expensive, given the polarity of the interest-group interests.

Alternatively, agents in a market economy can always introduce new commodities and information without government regulation. Effective labeling, however, requires segregation or an identity preservation system, and we have shown that significant costs and risks exist with these systems. For example, farmers who currently produce GM and non-GM crops and handlers who handle both GM and non-GM versions of a commodity have an incentive to commingle the cheaper GM with the higher valued non-GM. The "bad" commodity could drive out the "good." However, in Europe, when GM foods were labeled, the international NGOs demonstrated heavily against the stores where they were sold, consumer demand dropped significantly, and grocery store managers removed the GM-labeled products from store shelves. This is an example of the "good" driving out the "bad," but not an example of labeling providing consumers with a broader set of choices.

The key question is whether the market will support such information, which would be costly and supplied by producers, handlers, and (or) processors. Given that providing GM information is currently voluntary in the United States and that consumers have revealed that the non-GM or GM-free is the superior product, a voluntary signaling equilibrium would be one where non-GM or GM-free is the commodity that would be certified. Currently, this is not happening, except to the extent that Certified Organic cannot use genetic engineering in the production process, and consumers can purchase Certified Organic foods.

Consumers and growers must make consumption and production decisions and rely frequently on interested parties to provide at least part of the information for these decisions. For example the Food and Drug Administration and Environmental Protection Agency have limited resources for conducting independent research on the effects of new biotech products. We could legislate that producers or suppliers knowingly giving false declaration is a crime, but proving falsification to an independent third-party, e.g. a court, is frequently difficult. Hence, principals and agents frequently enter into contracts that are not enforceable by courts or by a third party. This requires that the contracts, whether written or oral, be incentive compatible, i.e. it is in the interest of both parties to carry out their terms of the contract without going to court, and furthermore monitoring by either party is socially wasteful!

In contrast, with the current U.S. food system, the introduction of independent, third-party information on genetic modification has the potential of being social welfare improving. However, it would most likely have to be financed by the federal government but operated as an independent institution. The primary objective of this institution would be to verify claims from the biotech industry and environmental groups and supply objective information to the public. This approach could force interested parties to reveal more information than would otherwise be possible. I suggest that this type of institution building would be considered "social welfare improving" for the United States and provide international public goods to much of the rest of the world.

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